Field testing of the FIuenta WIOM 300 - Water-In-Oil Monitor

L Farestvedt

L Farestvedt: **Field testing of the Fluenta WIOM 300 - Water-In-Oil Monitor**
The North Sea Flow Measurement Workshop, October 1994

SUMMARY

The Fluenta WIOM 300, High Precision Water-In-Oil Monitor, is a full-bore, in-line, real-time and non-intrusive watercut (BS&W) monitor that meets the requirements of fiscal and custody transfer metering of oil. The monitor is delivered in two versions; one covering 0 to approximately 70% watercut, the other covering the full 0-100% watercut range.

The paper includes a brief technical introduction to the WIOM 300, after which typical results from four of the more recent installations are presented.

These are: Statoil - Gullfaks A, where it was tested for long term stability
Statoil - Mongstad, where it was tested for high accuracy applications
Mærsk - Gorm E, where it was tested with unpredictable mixtures of crude oils
Schlumberger - France, where it was tested with high watercuts and free gas

The conclusion of these and other tests is that the Fluenta WIOM 300 is a reliable and field proven instrument for essentially any watercut measurement application.

CONTENTS

1 INTRODUCTION

The Fluenta Water-In-Oil Monitors are non-intrusive and full-bore watercut meters (BS&W) that continuously measures the water content of water/oil mixtures. They have no objects intruding into the flow, and no by-pass lines are required.

Two versions are available; the **High Precision Water-In-Oil Monitor, WIOM 300,** and recently also the **Full Range Water-In-Oil Monitor, WIOM 300F.** As the names imply, the WIOM 300 is optimized for the lower watercut range (where it meets the requirements of fiscal and custody transfer metering of oil), while the WIOM 300F covers the full 0-100% watercut range. Both versions have wide temperature and pressure ranges, and are reliable instruments with essentially no maintenance requirements.

1.1 Principle of operation

The WIOM 300 consists of a capacitance sensor, sensor electronics, cables, safety barriers, and a system computer. The arrangement, and the location of the different components, are shown in figure 1.

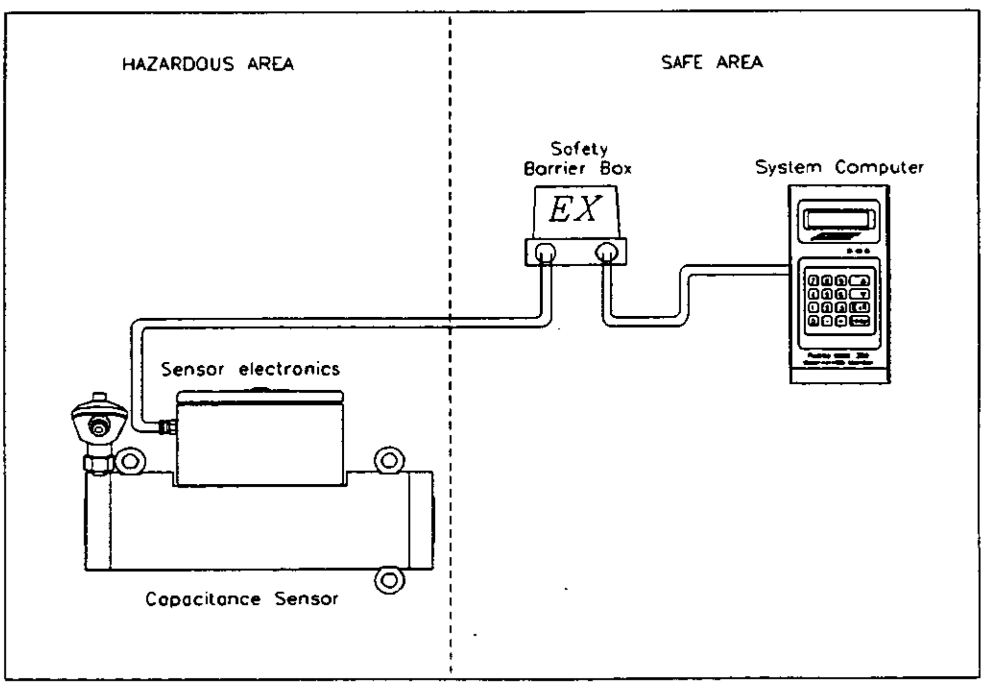

Figure 1: Arrangement of the WIOM 300.

The purpose of the capacitance sensor is to position the oil/water mixture as the dielectric in a capacitor, in such a way that as much as possible of the electrical field induced by the sensor passes through the mixture. The permittivity (dielectric constant) of the mixture can then be determined.

By placing an electrode on each side of the pipe, and allowing the mixture to flow through the pipe, the electrical field between the electrodes will be affected by the permittivity of the water/oil mixture, and the capacitance measured between the electrodes will vary according to the amount of water in the mixture.

The electrical field is not affected by the velocity of the mixture, and experiments at Christian Michelsen Research (CMR) have shown that the sensor concludes with the same water fraction at a velocity of 3 m/sec as at 0 m/sec. After a period with no flow, however, the readout will change as a result of the water separating from the mixture. Furthermore, a capacitance sensor, such as the WIOM 300, will not be affected by the salinity of the water. This corresponds with the theory, and has also been verified by tests.

The WIOM 300F utilize the same capacitance sensor as the WIOM 300, but in addition also makes use of an inductance sensor. By placing two toroids on the outside of a non-conductive liner, a constant current is induced through the oil/water mixture. Two potential electrodes (placed between the two toroids) detect the voltage drop, which is dependent of the conductivity of the oil/water mixture. Since the conductivity is very different from water to oil, the differential voltage measured will vary according to the amount of water in the mixture. These readings are not affected by the velocity nor the pressure of the mixture. Each of the two spool pieces of the WIOM 300F have separate sensor electronics, cables and safety barriers, while they are both run by the same system computer.

The relation between watercut and permittivity/conductivity is shown in figure 2.

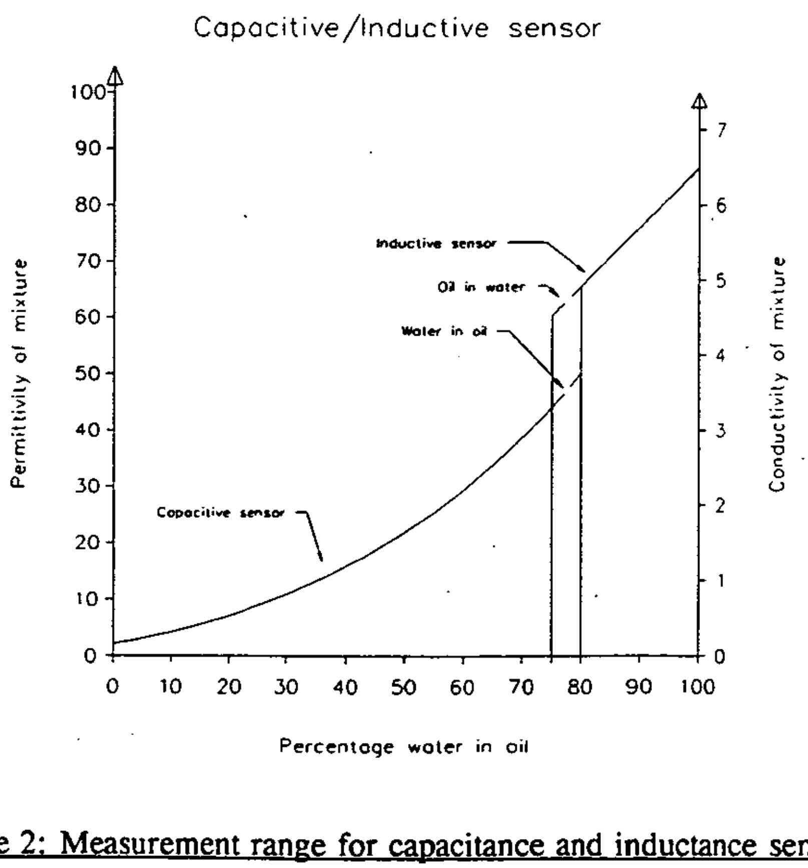

Figure 2: Measurement range for capacitance and inductance sensors.

1.2 Applications

The WIOM 300 and WIOM 300F, with their high accuracy and wide measurement range, are suitable for a number of applications. Figure 3 and 4 presents the uncertainty for the 0-10 and 0-100% watercut range.

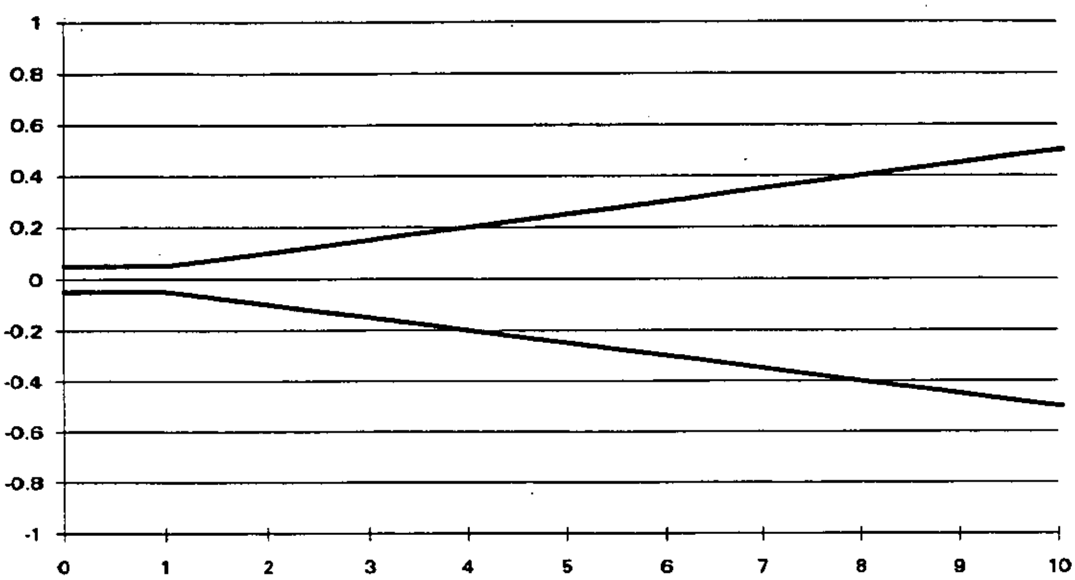

Figure 3: Absolute uncertainty for 0-10% watercut.

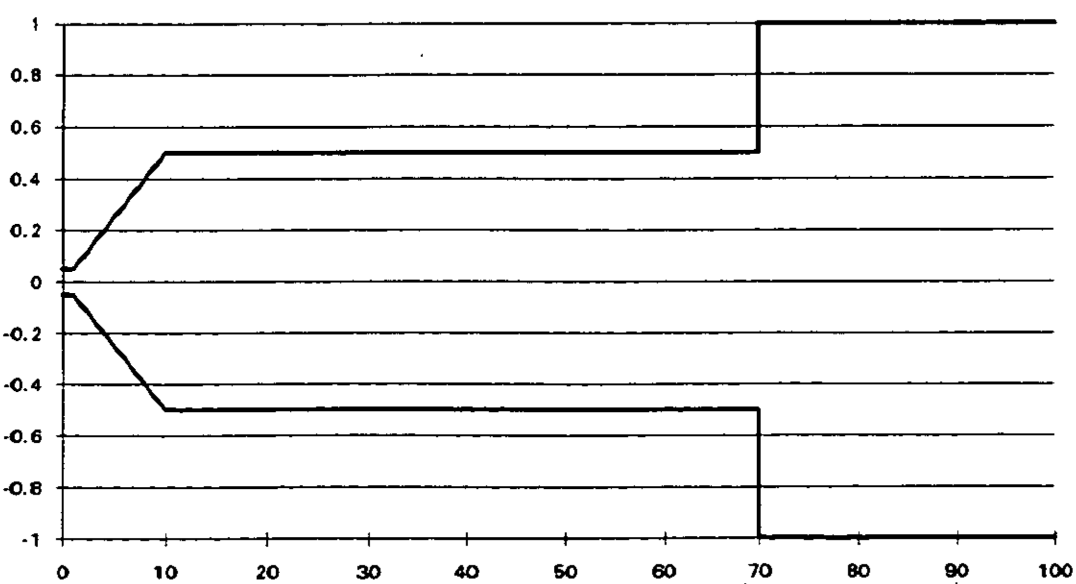

Figure 4: Absolute uncertainty for 0-100% watercut.

The following are some of the applications for the WIOM 300 and WIOM 300F:

* The extremely low uncertainty makes the WIOM 300 a reliable instrument for fiscal and custody-transfer metering of oil.

* The full-profile, non-intrusive and very accurate sensor makes the WIOM 300F well suited for continuous and accurate monitoring of the liquid legs of a separator. The WIOM 300F consists of two spool-pieces, one capable of measuring the water content of the oil leg, and one capable of measuring the oil content of the water leg. A single flow computer performs the algorithms from both sensor units.

* The high measurement range and the full-profile, non-intrusive design guarantees the user a correct and optimized production metering for allocation, and will also ensure an optimized water-flood production.

* The full-profile design enables installation in pipelines of 1" to 16" inner diameter without having to build a by-pass loop. The high temperatures and pressures that sometimes are present in these pipelines, are also handled with the high temperature and high pressure versions.

For these and many other applications, the Fluenta Water-In-Oil Monitors will increase the efficiency substantially, and result in significant cost-reductions and profit gains. The WIOM 300 and WIOM 300F are certified by BASEEFA according to European Standards, suitable for zone 0 area (corresponding to Division 1 in North America), for temperature class T4 (EEx ia T4).

1.3 Recent improvements

Since the market introduction in 1989, the WIOM 300 series has been through a number of design improvements. The latest of these is in regards to the non-conductive liner, which enables us to use the capacitance technology to detect the watercut, and at the same time also have a completely non-intrusive design.

The first version of the WIOM 300 made use of a ceramic liner. However, for some applications we experienced a surface film developing on the inside of the liner. This resulted in an increased capacitance, and over-estimation of watercut. The ceramic liner has thus been changed to a TK2 coated Boro Cilicate liner, with which the surface film does not occur.

2 FIELD TESTING OF THE FLUENTA WIOM 300

The WIOM 300 has been on the marked since 1989, and has since been installed and tested at a number of installations. Some of these are discussed on the following pages.

2.1 Statoil - Gullfaks A; long term stability

Statoil purchased a WIOM 300, which was installed on the Gullfaks A platform in the North Sea during the beginning of August 1992. The WIOM 300 continuously monitors the water content of the exported oil, and the operators are very satisfied with the Fluenta instrument. Some of the initial results are shown in figure 5.

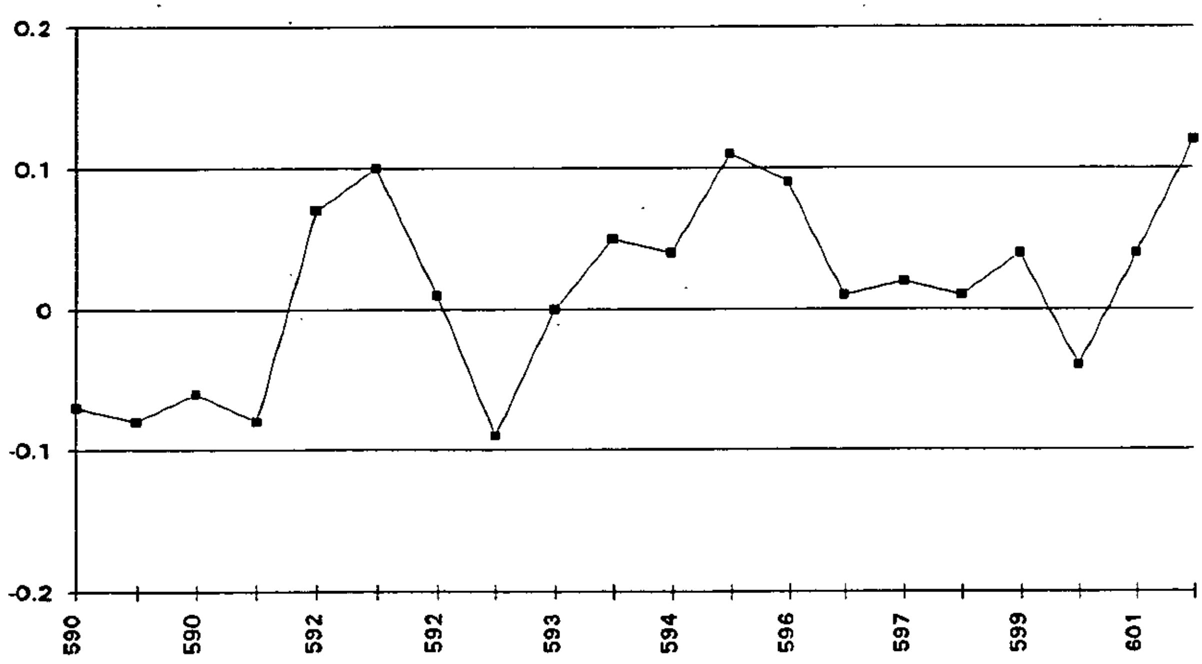

Figure 5: Deviation for different Cargo's during August / September 1992.

The monitor has also since performed to the operators satisfaction. It has shown a slight dependency on temperature variations, and the operators have to adjust for this during loading of the oil tankers. The offset is in the order 0.2%, and is constant throughout the tanker loading.

Since the installation at Gullfaks A, Fluenta has improved the temperature calibration routines, and the dependency to temperature variations is now essentially eliminated (ref. Statoil - Mongstad test described in part 2.2 of this paper).

As the monitor has performed without any problems for over two years, it has proven the stability of the essentially "maintenance free" WIOM 300.

2.2 Statoil - Mongstad; high accuracy applications

The Fluenta High Precision Water-In-Oil Monitor, WIOM 300, was during the time period September -92 to February -93 thoroughly tested through a field test performed by Statoil at the Mongstad refinery outside Bergen. The tests included testing of three different crude oils, with watercut varying from 0 to 10%. The different crudes (Gullfaks A/B, Gullfaks C and Statfjord crude), have quite different electrical and physical properties. The test has thus enabled us to check the instrument's performance for a variety of different crude oils. Results from testing Gullfaks C crude are shown in figure 6.

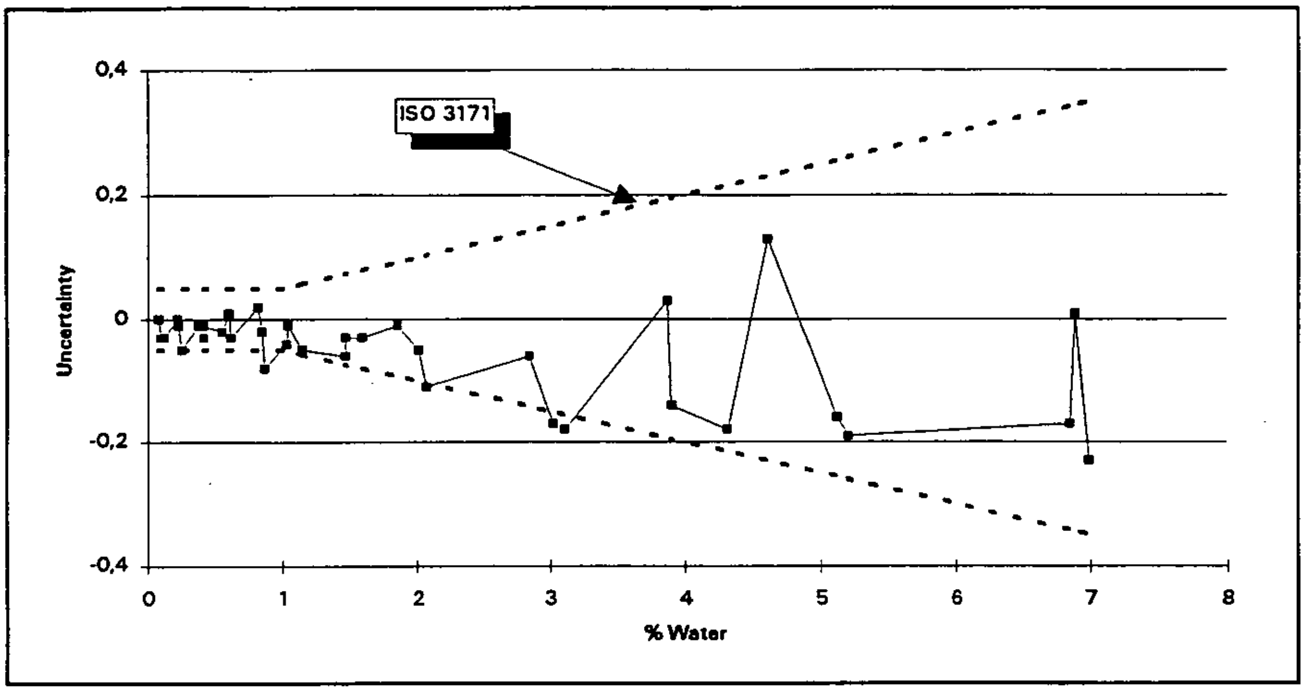

Figure 6: Deviation from Karl Fisher titration for 0-7% watercut.

In addition to the above mentioned tests, the WIOM 300 was tested in regards to temperature variation of the flow and the electronics, and to variation of pressure and flowrate. The monitor proved to be independent of pressure, flowrate and flow temperature. Furthermore, the monitor had only a minor dependency to the electronics temperature, where a variation of 20°C resulted in an error of 0.06% water.

2.3 Mærsk - Gorm E; unpredictable mixtures of crude oils

A WIOM 300 was installed at the offshore Gorm E platform in the middle of January 1993, and was tested for approximately one year. The WIOM 300 monitors the watercut of the export line transporting crude from the different oil producing fields in the Danish sector of the North Sea to shore. The crudes have very different electrical properties, which makes this installation complex and difficult for an in-line and continuous watercut monitoring. The rapid changes in oil type and watercut also makes it difficult to test the monitor, as the sampled oil/water mixture often is not representative to the mixture in the monitor.

The readings from the WIOM 300 has been checked every 4 hours against the water content of samples, determined by the centrifuge method. Due to the variations in crude composition, and with basis in the samples taken, the monitor has been re-calibrated once every two weeks to obtain a best possible coherence with the samples.

Typical results from the installation period are shown in figure 7, where the specified absolute uncertainty also is plotted.

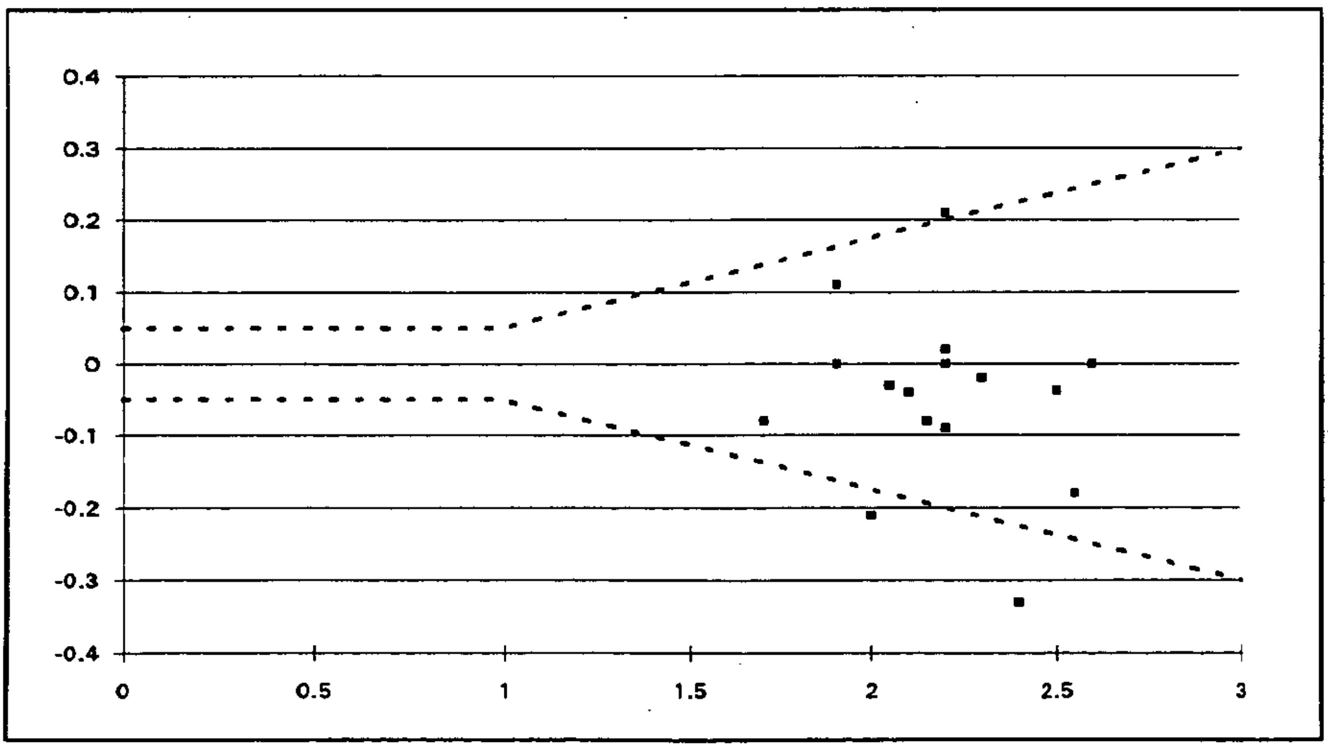

Figure 7: Deviation from centrifuge.

The conclusion of the test is that the application is extremely difficult due to the great variation of oil type, and to the rapid variation of watercut. The major problem is, however, not the monitor's ability to determine the watercut of the mixture, but to verify that the measured value is correct. As the conditions change constantly, it is virtually impossible to get a representative sample.

2.4 Schlumberger - France; high watercuts and free gas

Schlumberger tested a WIOM 300 in the time period March to July 1993. The program included testing for watercuts of 5-30% and void fractions of 0-40%. The test showed that the WIOM 300 performed within its specified uncertainties for the entire watercut range.

Figure 8 presents the results for 3 to 25% watercut.

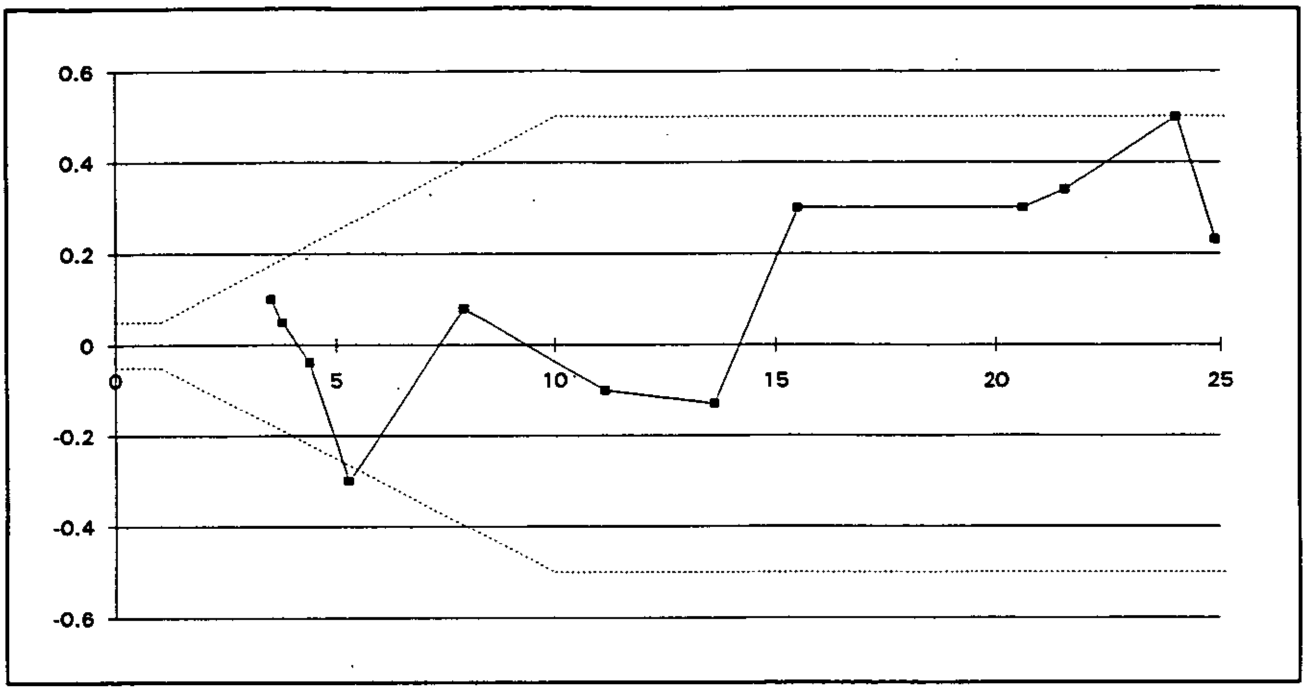

Figure 8: Deviation for watercuts of up to 25%.

The WIOM 300 was also tested for void fractions of up to 40%. It proved to be a linear dependency to the volume of free gas up to approximately 15% gas fraction. Above that level, the monitor had substantially higher uncertainties. As figure 9 shows, the WIOM 300 has a dependency of free gas in the water/oil mixture where 1% gas results in a negative error of approximately 0.1% watercut.

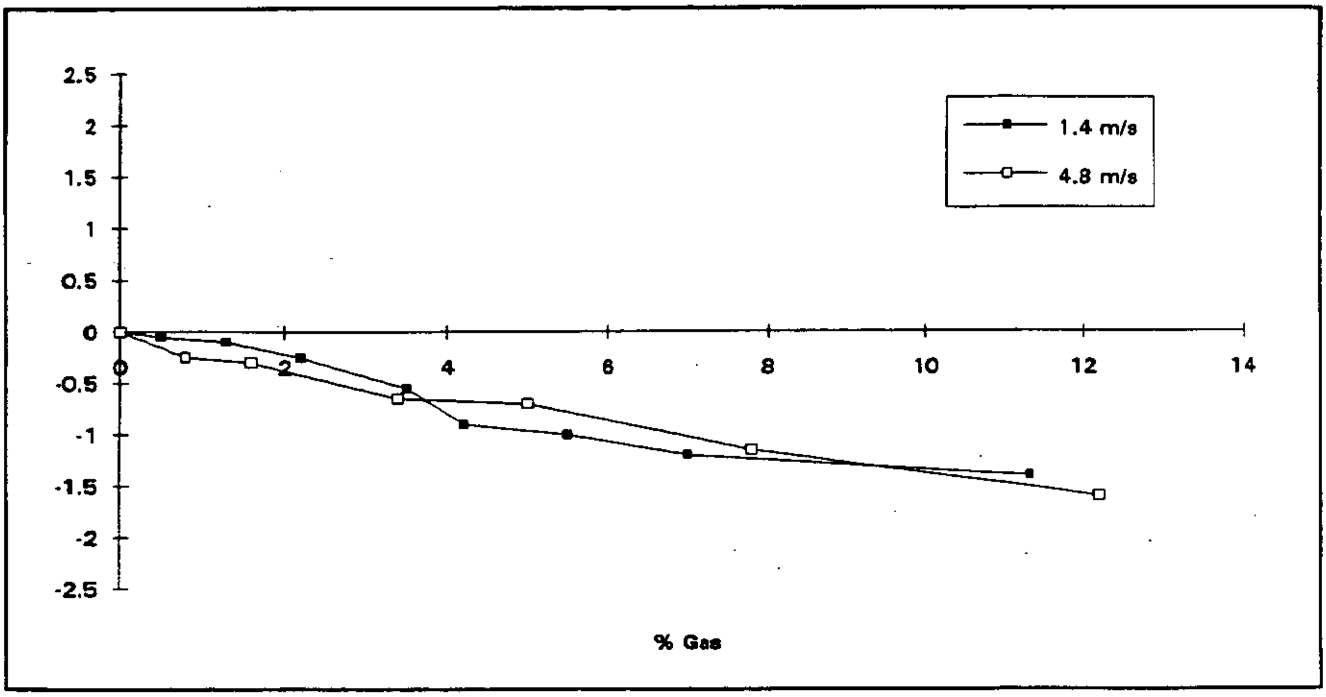

Figure 9: Deviation for 10% watercut.

3 CONCLUSIONS

As the tests described in part 2 of the paper show, the Fluenta WIOM 300 is a fully field proven instrument that can be used for a number of different applications.

The monitor is extremely reliable and essentially maintenance free. It can be used for applications where fiscal accuracy is required, and also for applications where water content is expected to vary over the full 0-100% watercut range.

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.